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Maruyama et al.

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(54) IMAGE FORMING APPARATUS INCLUDING CHARGERS AND A CURRENT DETECING UNIT THAT DETECTS A SUM OF CURRENTS OF THE CHARGERS

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G03G 15/02 (2006.01)
G03G 15/01 (2006.01)

(52) **U.S. Cl.**
CPC ***G03G 15/0283*** (2013.01); ***G03G 15/0194*** (2013.01)
USPC **399/50**; 399/100

(58) **Field of Classification Search**
USPC 399/100, 89, 88, 90, 128, 171, 50
See application file for complete search history.

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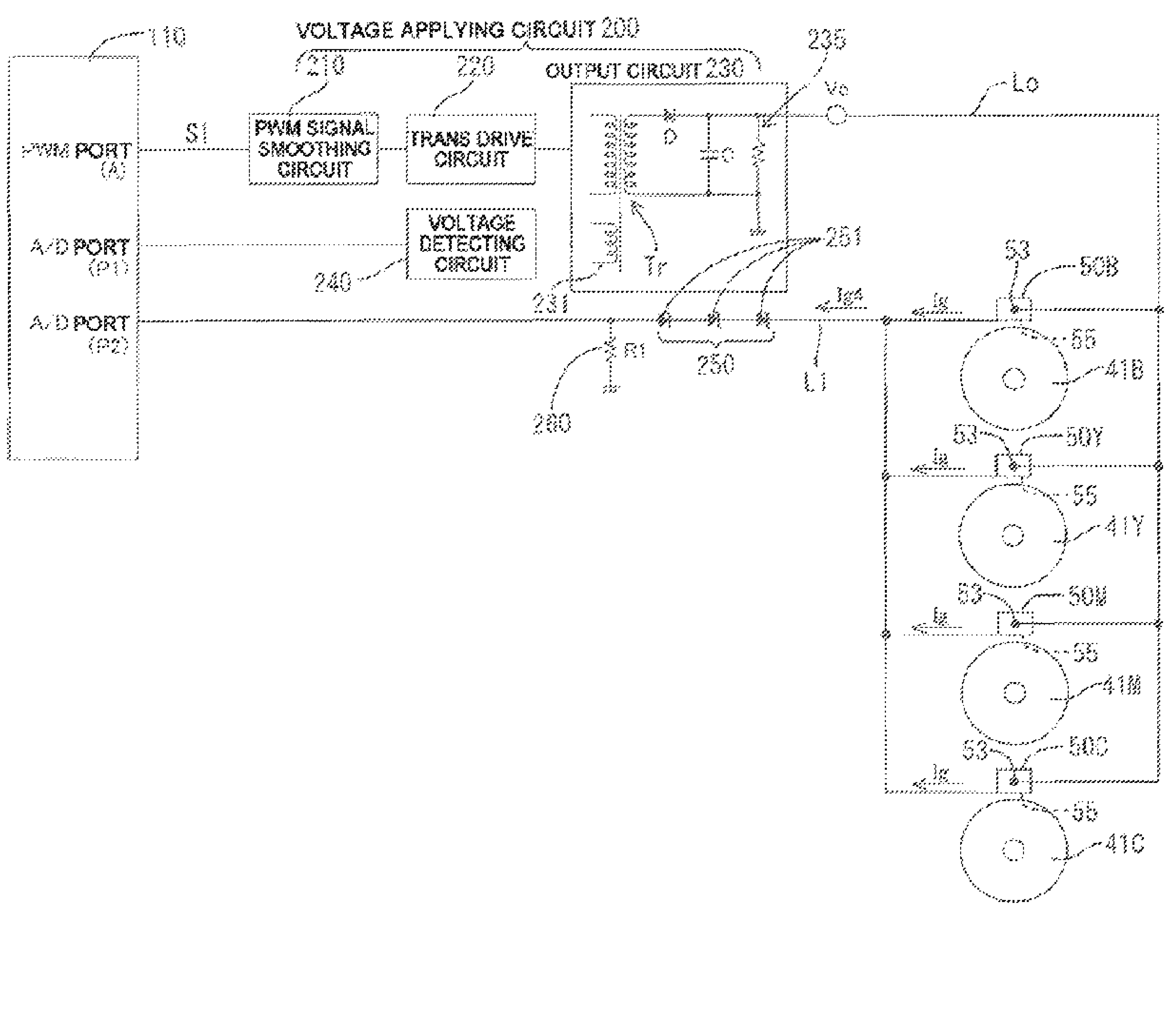
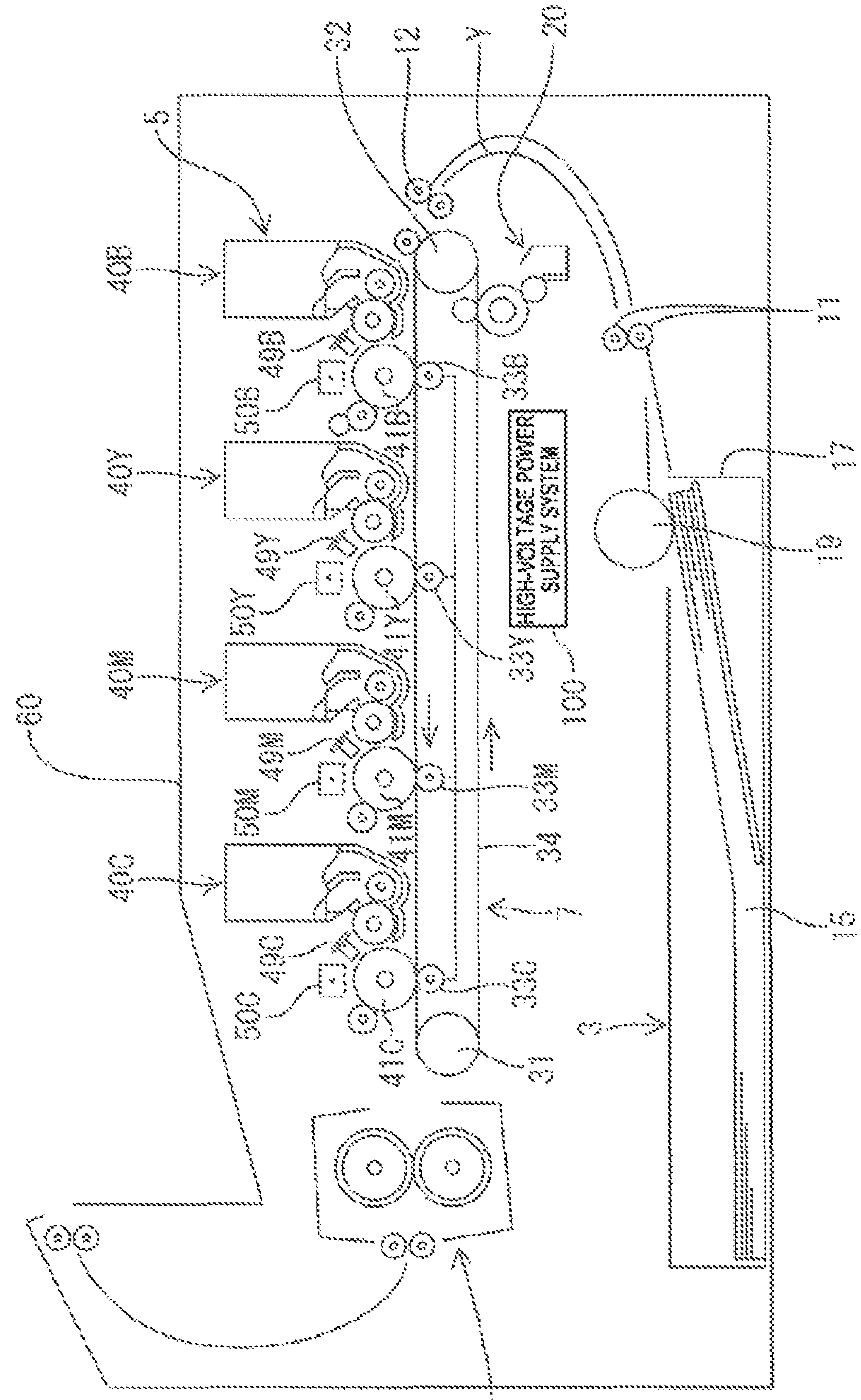
(57) **ABSTRACT**

An image forming apparatus, includes: at least one photosensitive element; a plurality of chargers configured to charge the at least one photosensitive element; a voltage applying circuit commonly connected to the plurality of chargers and configured to apply a voltage to the plurality of chargers; a current detecting unit configured to detect a current sum of current that flows to the plurality of chargers from the voltage applying circuit; and a control device configured to control the voltage applying circuit so that the current sum detected by the current detecting unit becomes equal to or larger than a reference value.

12 Claims, 12 Drawing Sheets

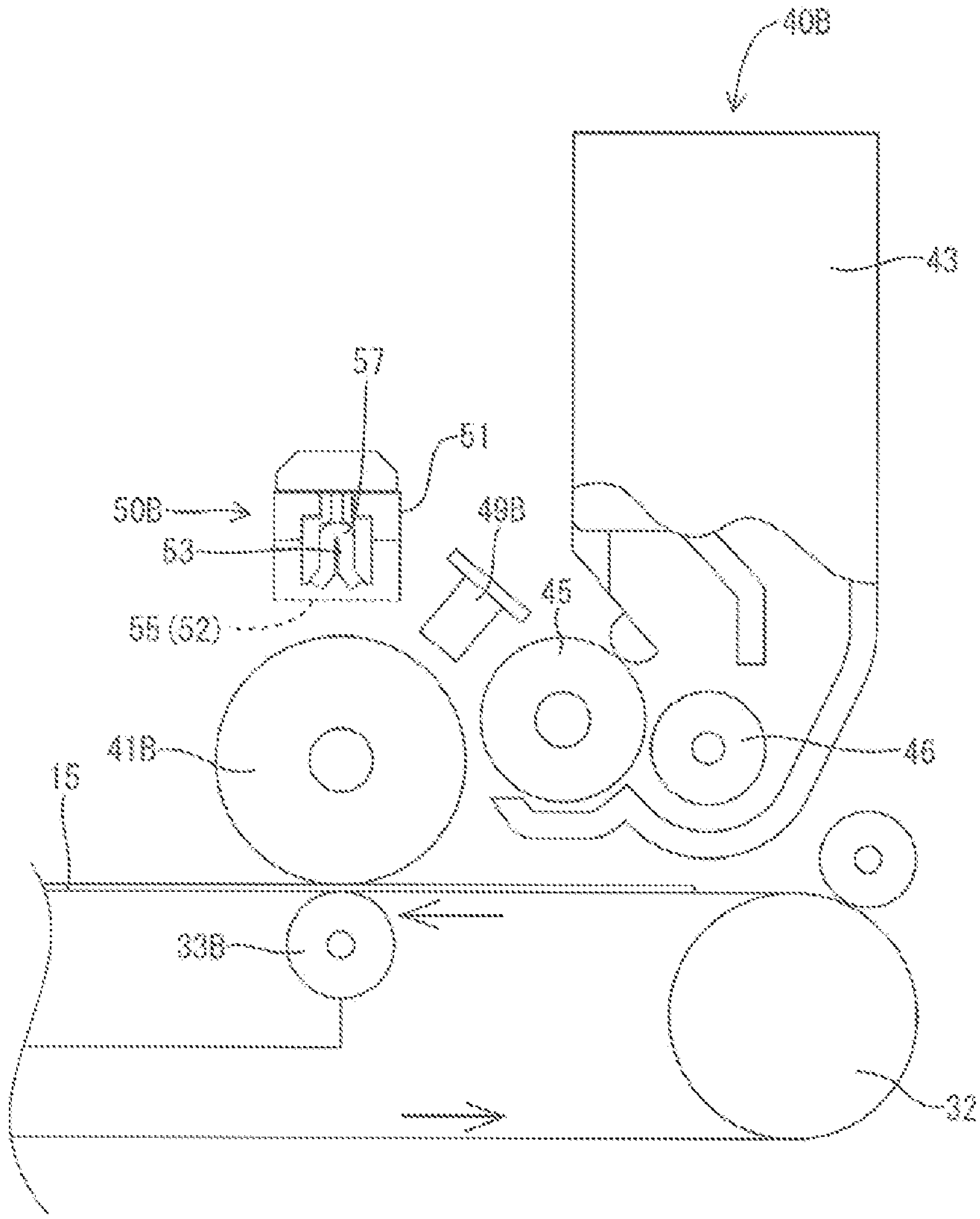




HIGH-VOLTAGE POWER SUPPLY SYSTEM
100
5
20
32
12
11
17
19
16
3
7
9
31
34
60
40B
40Y
40M
40C
41B
41Y
41M
41C
33B
33Y
33M
33C
49B
49Y
49M
49C
50B
50Y
50M
50C

FIG. 1

FIG. 2



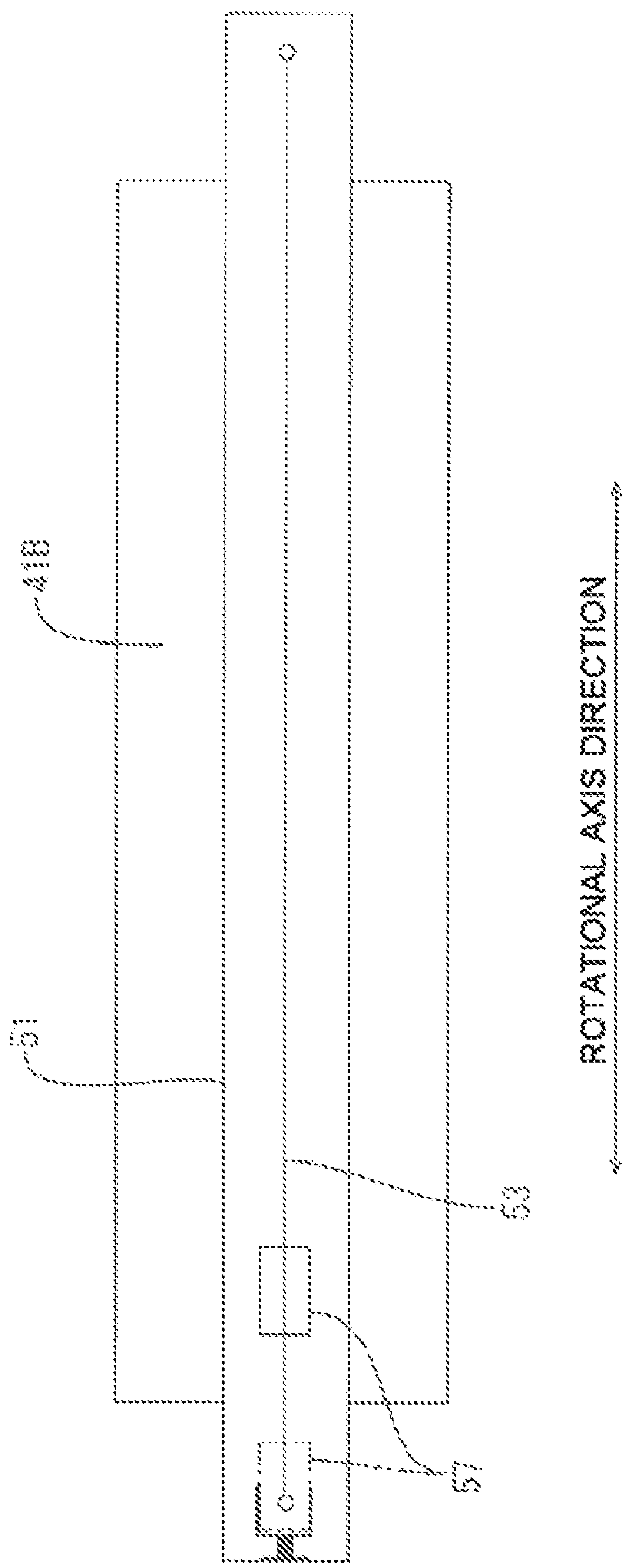


FIG. 3

FIG. 4

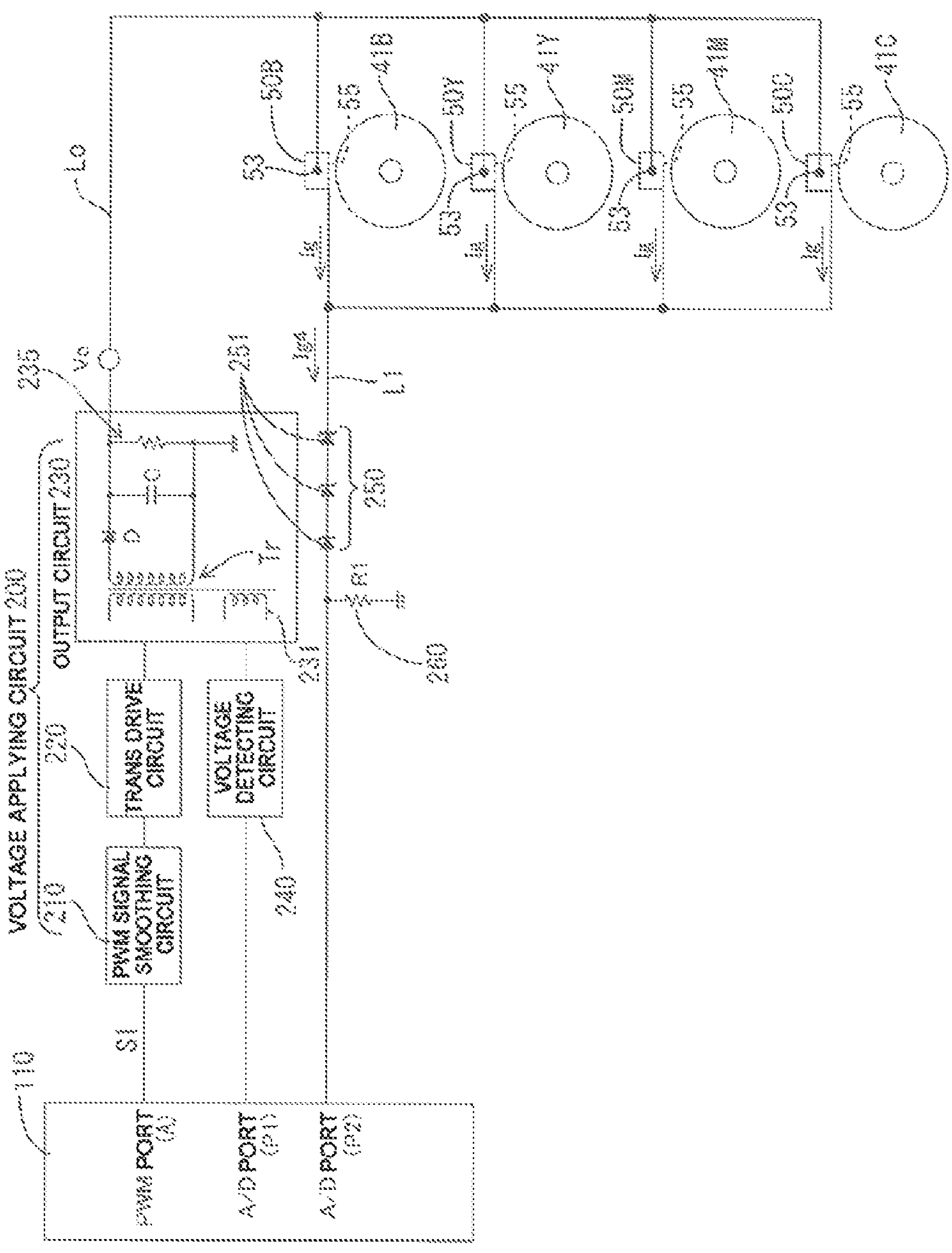

110
PWM PORT (A)
A/D PORT (P1)
A/D PORT (P2)
S1
VOLTAGE APPLYING CIRCUIT 200
210
PWM SIGNAL SMOOTHING CIRCUIT
220
TRANS DRIVE CIRCUIT
240
VOLTAGE DETECTING CIRCUIT
OUTPUT CIRCUIT 230
Tr
D
C
231
235
Vo
251
250
R1
260
L1
Lo
50B
50Y
50M
50C
53
55
41B
41Y
41M
41C

FIG. 5

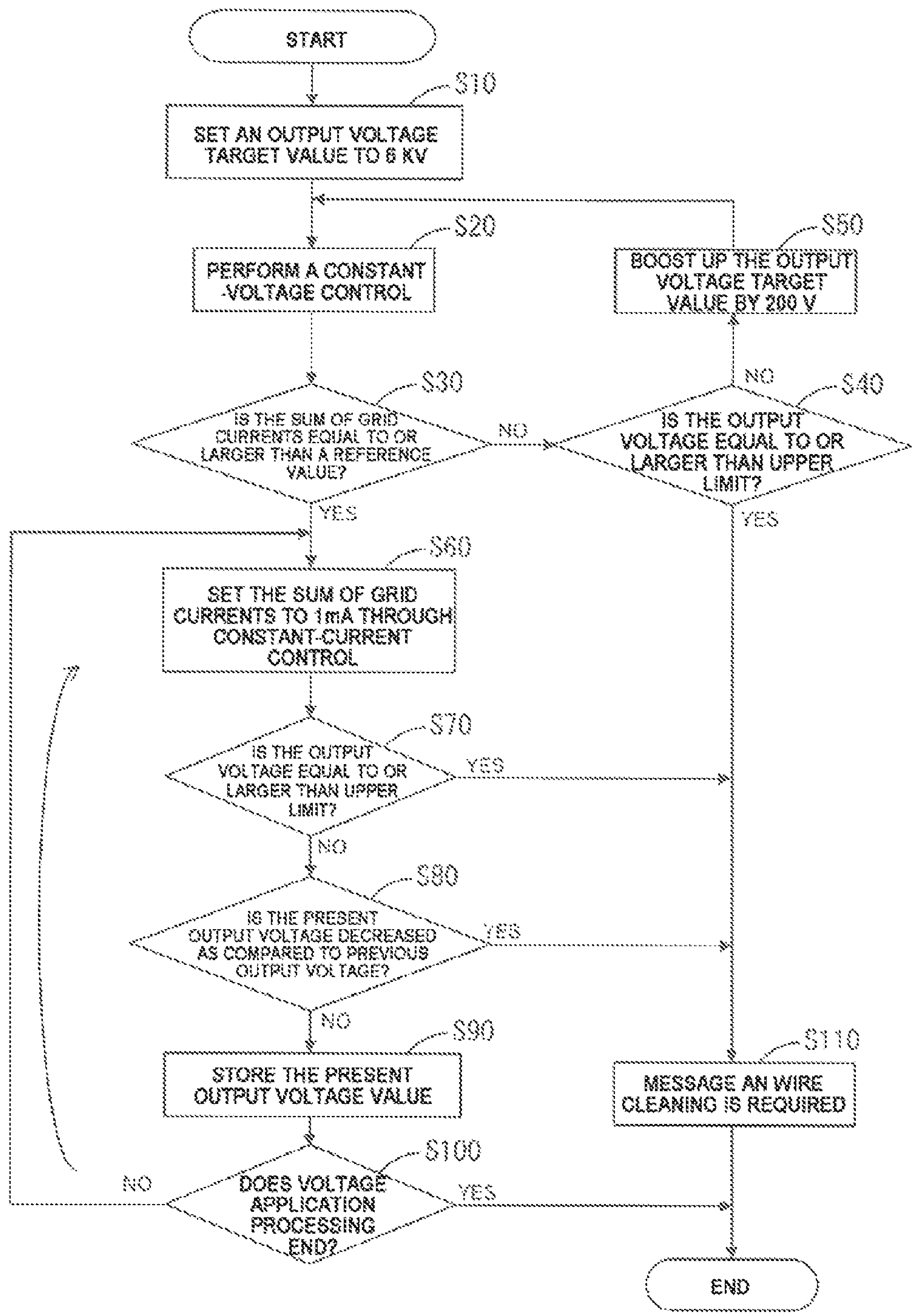

START
S10
SET AN OUTPUT VOLTAGE TARGET VALUE TO 6 KV
S20
PERFORM A CONSTANT -VOLTAGE CONTROL
S50
BOOST UP THE OUTPUT VOLTAGE TARGET VALUE BY 200 V
S30
IS THE SUM OF GRID CURRENTS EQUAL TO OR LARGER THAN A REFERENCE VALUE?
NO
S40
IS THE OUTPUT VOLTAGE EQUAL TO OR LARGER THAN UPPER LIMIT?
NO
YES
YES
S60
SET THE SUM OF GRID CURRENTS TO 1mA THROUGH CONSTANT-CURRENT CONTROL
S70
IS THE OUTPUT VOLTAGE EQUAL TO OR LARGER THAN UPPER LIMIT?
YES
NO
S80
IS THE PRESENT OUTPUT VOLTAGE DECREASED AS COMPARED TO PREVIOUS OUTPUT VOLTAGE?
YES
NO
S90
STORE THE PRESENT OUTPUT VOLTAGE VALUE
S110
MESSAGE AN WIRE CLEANING IS REQUIRED
S100
DOES VOLTAGE APPLICATION PROCESSING END?
NO
YES
END

FIG. 6

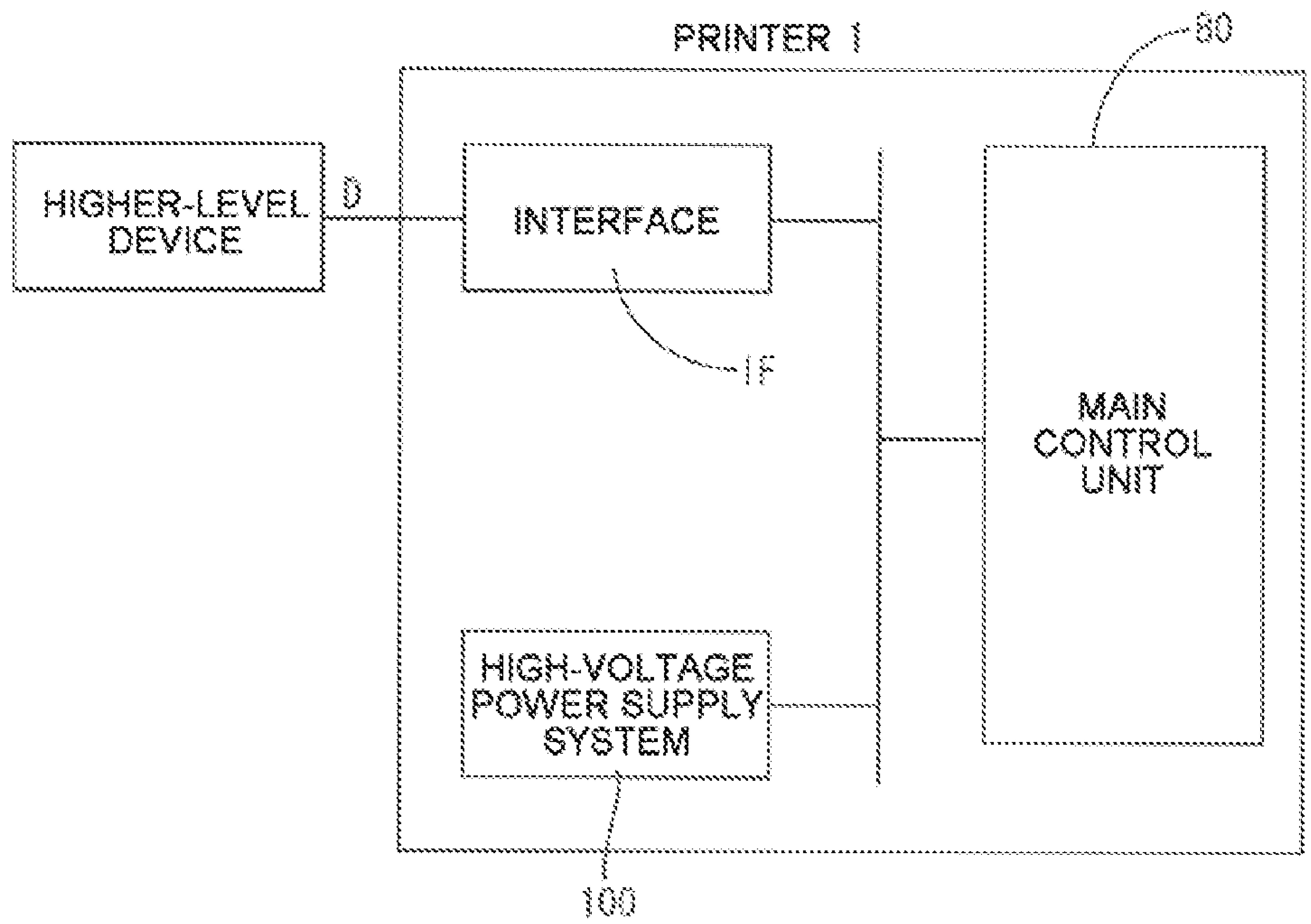

PRINTER 1
80
HIGHER-LEVEL DEVICE
D
INTERFACE
IF
MAIN CONTROL UNIT
HIGH-VOLTAGE POWER SUPPLY SYSTEM
100

FIG. 7

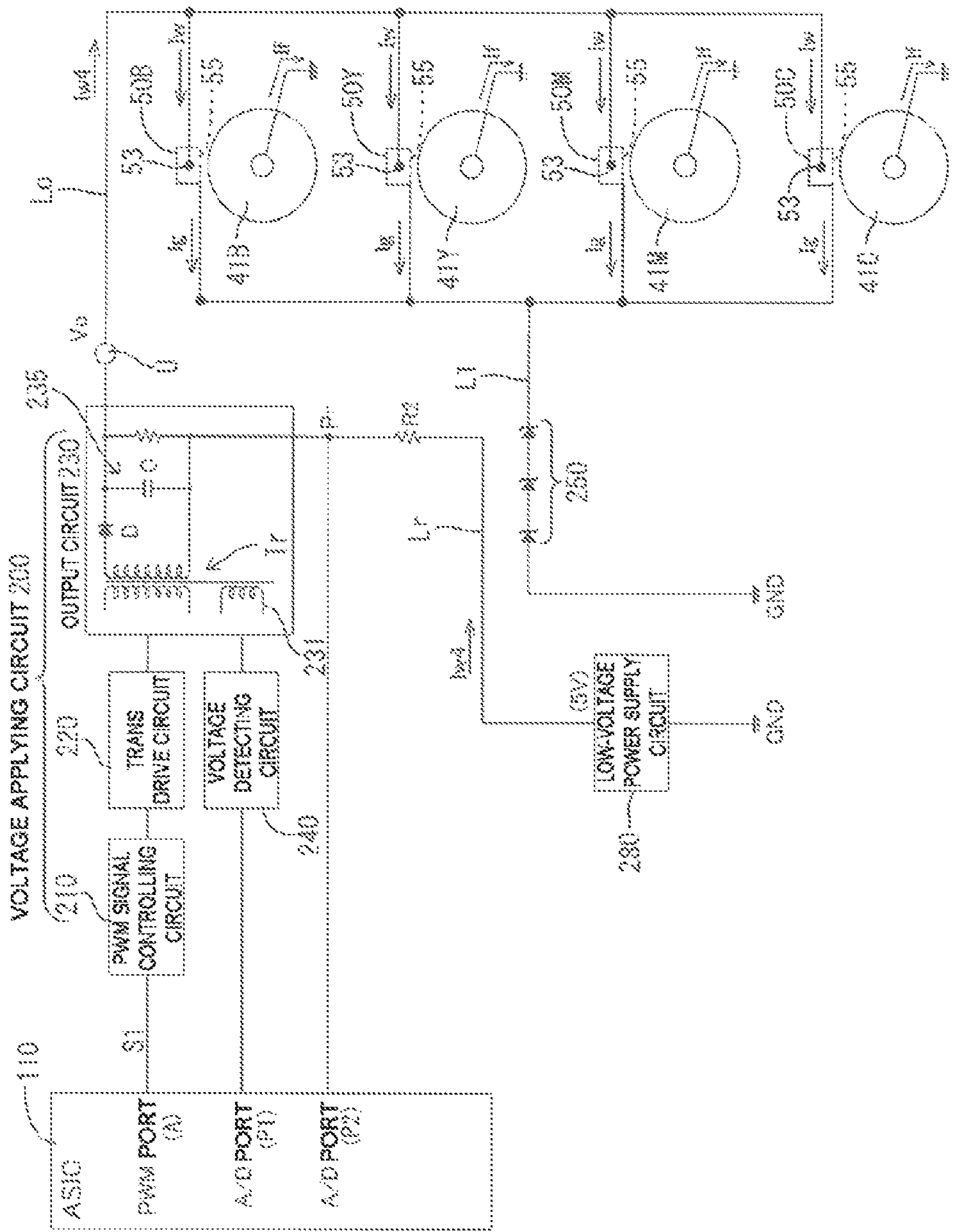

ASIC
110
PWM PORT (A)
A/D PORT (P1)
A/D PORT (P2)
S1
PWM SIGNAL CONTROLLING CIRCUIT
210
TRANS DRIVE CIRCUIT
220
VOLTAGE DETECTING CIRCUIT
240
VOLTAGE APPLYING CIRCUIT 200
OUTPUT CIRCUIT 230
231
Tr
D
C
235
Vo
O
Lo
Pr
Ra
Lr
L1
250
GND
Iw4
(5V)
LOW-VOLTAGE POWER SUPPLY CIRCUIT
290
GND
50B
50Y
50M
50C
53
55
41B
41Y
41M
41C

FIG. 8

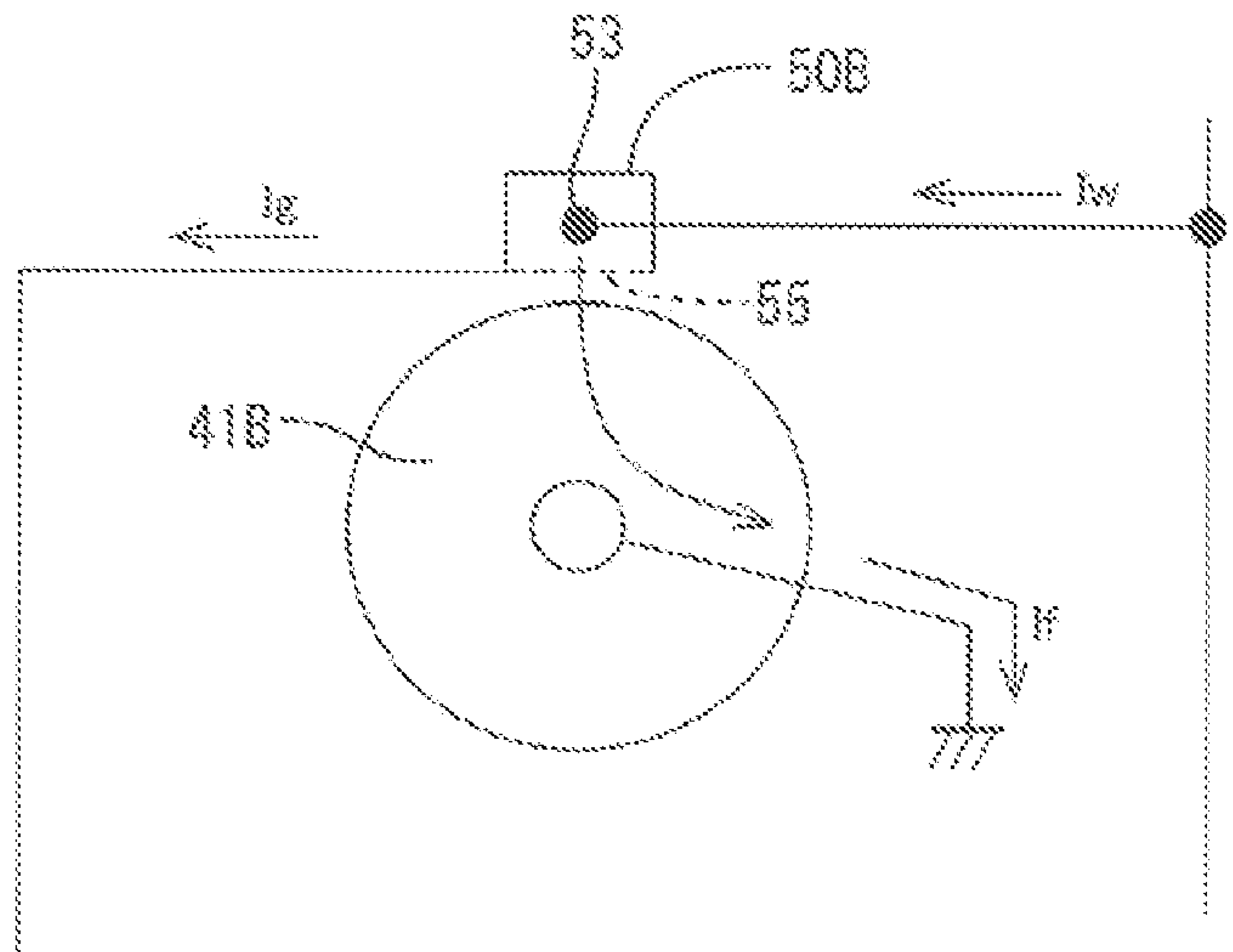


FIG. 9

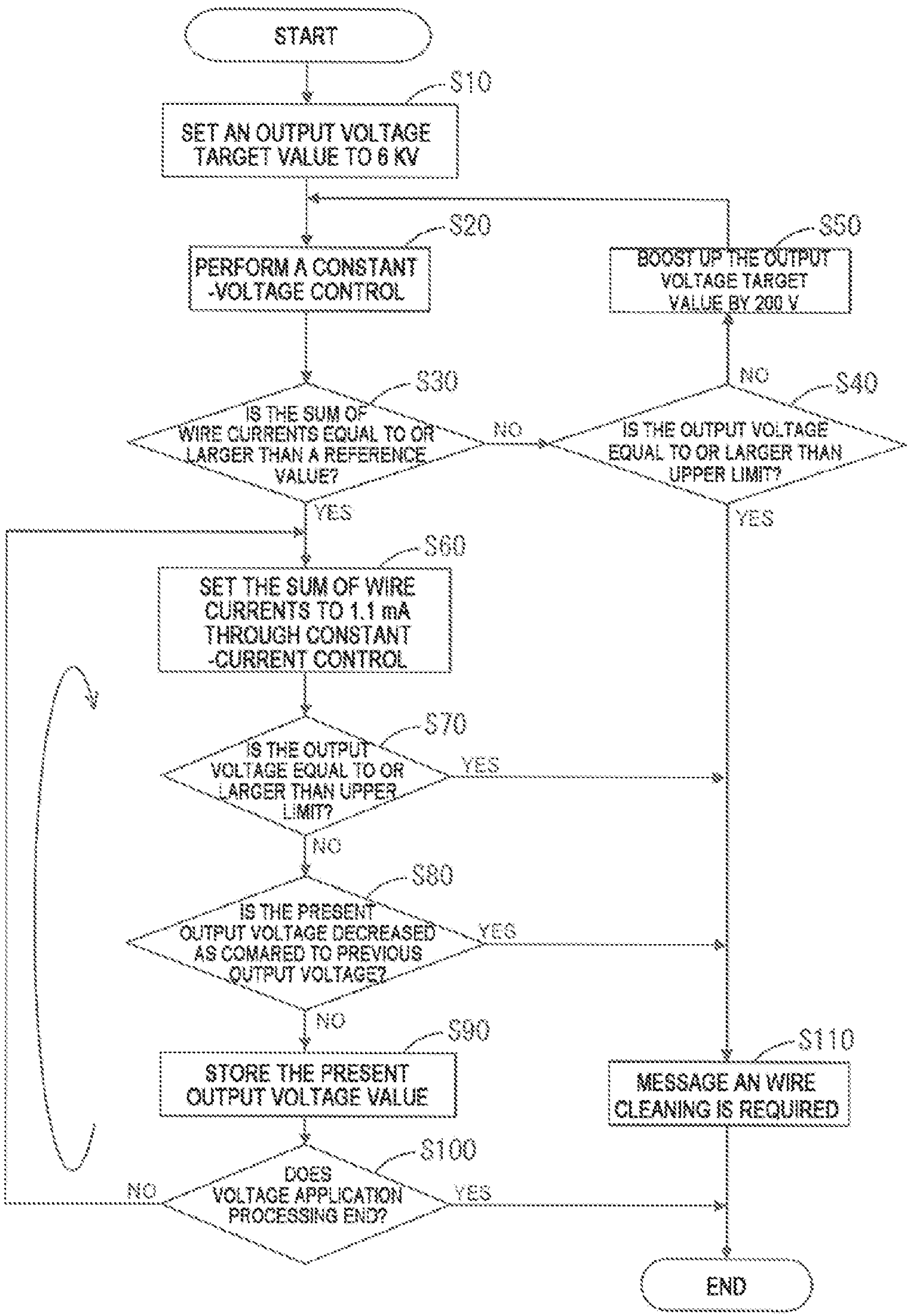

START
S10
SET AN OUTPUT VOLTAGE TARGET VALUE TO 6 KV
S20
PERFORM A CONSTANT -VOLTAGE CONTROL
S50
BOOST UP THE OUTPUT VOLTAGE TARGET VALUE BY 200 V
S30
IS THE SUM OF WIRE CURRENTS EQUAL TO OR LARGER THAN A REFERENCE VALUE?
NO
S40
IS THE OUTPUT VOLTAGE EQUAL TO OR LARGER THAN UPPER LIMIT?
NO
YES
YES
S60
SET THE SUM OF WIRE CURRENTS TO 1.1 mA THROUGH CONSTANT -CURRENT CONTROL
S70
IS THE OUTPUT VOLTAGE EQUAL TO OR LARGER THAN UPPER LIMIT?
YES
NO
S80
IS THE PRESENT OUTPUT VOLTAGE DECREASED AS COMARED TO PREVIOUS OUTPUT VOLTAGE?
YES
NO
S90
STORE THE PRESENT OUTPUT VOLTAGE VALUE
S110
MESSAGE AN WIRE CLEANING IS REQUIRED
S100
DOES VOLTAGE APPLICATION PROCESSING END?
NO
YES
END

FIG. 10

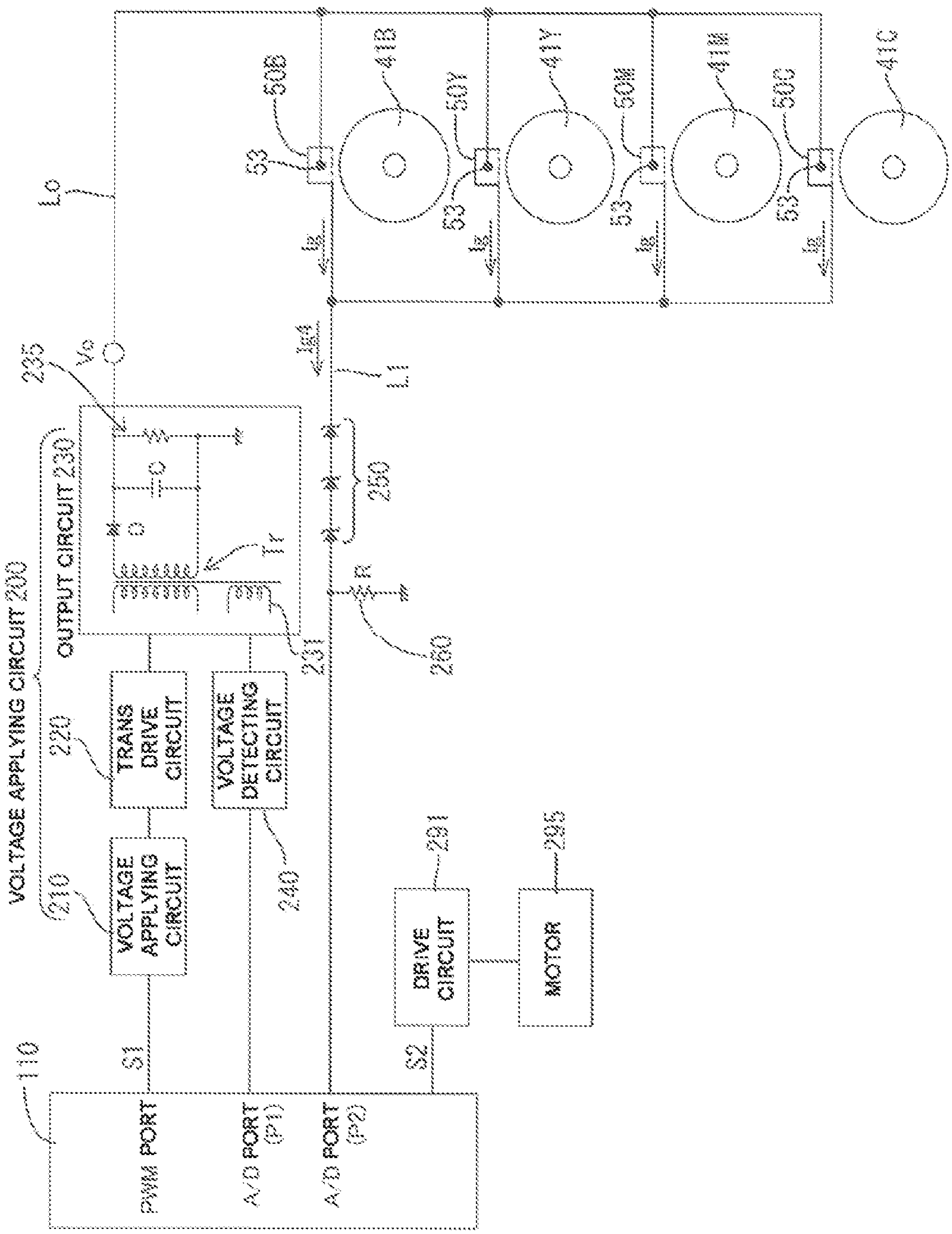

110
PWM PORT
A/D PORT (P1)
A/D PORT (P2)
S1
S2
VOLTAGE APPLYING CIRCUIT 200
210
VOLTAGE APPLYING CIRCUIT
220
TRANS DRIVE CIRCUIT
240
VOLTAGE DETECTING CIRCUIT
OUTPUT CIRCUIT 230
231
Tr
D
C
235
Vo
Lo
250
R
260
L1
Ig4
Ig
291
DRIVE CIRCUIT
295
MOTOR
50B
50Y
50M
50C
53
41B
41Y
41M
41C

FIG. 11

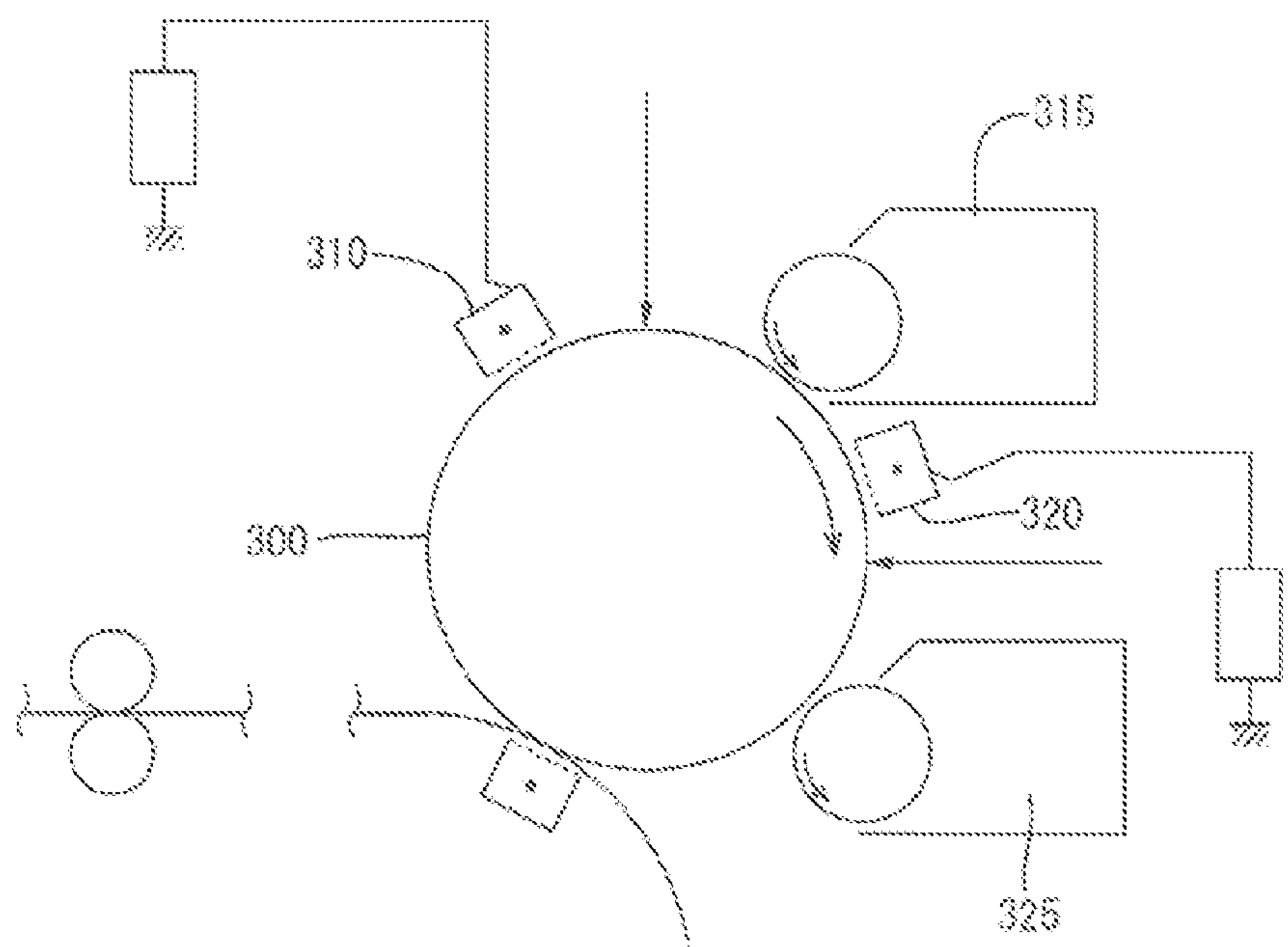


FIG. 12

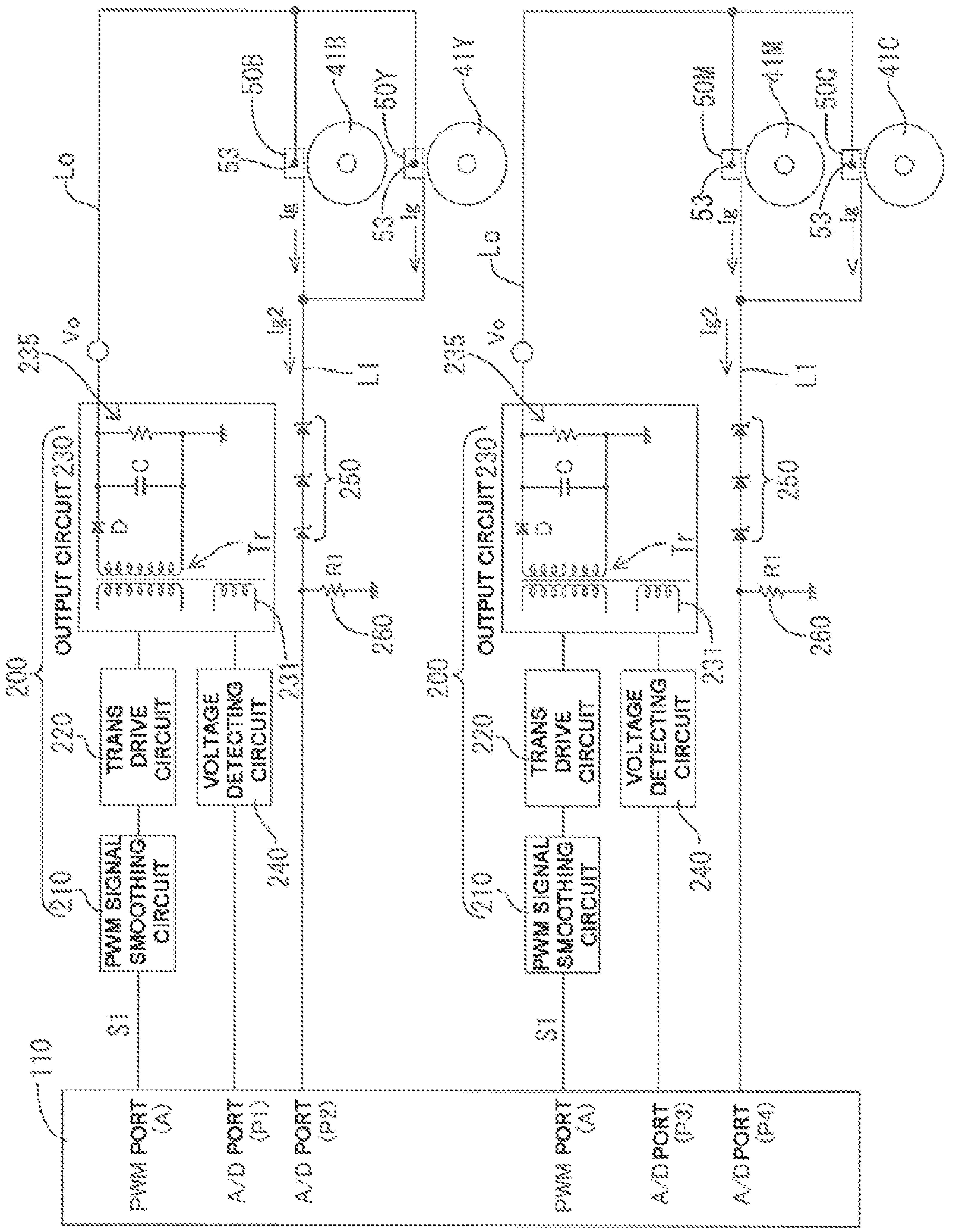

110
PWM PORT (A)
A/D PORT (P1)
A/D PORT (P2)
PWM PORT (A)
A/D PORT (P3)
A/D PORT (P4)
S1
200
210
PWM SIGNAL SMOOTHING CIRCUIT
220
TRANS DRIVE CIRCUIT
VOLTAGE DETECTING CIRCUIT
240
OUTPUT CIRCUIT 230
231
Tr
D
C
235
Vo
Lo
L1
250
R1
260
Ig2
Ig
53
50B
41B
50Y
41Y
50M
41M
50C
41C

IMAGE FORMING APPARATUS INCLUDING CHARGERS AND A CURRENT DETECING UNIT THAT DETECTS A SUM OF CURRENTS OF THE CHARGERS

This application is based upon and claims the benefit of priority of Japanese Patent Application No. 2010-170941 filed on Jul. 29, 2010, the contents of which are incorporated herein by reference in its entirety.

BACKGROUND

The present disclosure relates to an image forming apparatus.

Multi-color image forming apparatuses such as a color laser printer include a charger provided for each of developer colors (e.g., yellow, magenta, cyan, and black). Generally, reduction in the number of components and miniaturization of the apparatuses are sought by sharing a high-voltage power supply unit (e.g., a voltage applying circuit) applying high voltage to each charger in the above type of image forming apparatuses.

SUMMARY

A discharge amount of a charger decreases as the charger is being increasingly contaminated. Therefore, the charge amount of a photosensitive element becomes short, thereby an image quality may deteriorate. In order to prevent the image quality from being deteriorated due to the shortage of the charge amount of the photosensitive element, an amount of current may be controlled by detecting current that flows from a voltage applying circuit to each of the chargers. However, in this case, a current detecting unit needs to be provided in each charger, and as a result, the number of components increases.

The present disclosure has been made in an effort to solve the problem and one of the aspects of the present disclosure is intended to suppress the deterioration of the image quality through a configuration with minimum circuit components in an image forming apparatus in which the voltage applying circuit is being shared.

According to the aspect of the disclosure, there is provided an image forming apparatus, comprising:

at least one photosensitive element;

a plurality of chargers configured to charge the at least one photosensitive element;

a voltage applying circuit commonly connected to the plurality of chargers and configured to apply a voltage to the plurality of chargers;

a current detecting unit configured to detect a current sum of current that flows to the plurality of chargers from the voltage applying circuit; and

a control device configured to control the voltage applying circuit so that the current sum detected by the current detecting unit becomes equal to or larger than a reference value.

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** is a schematic cross-sectional view showing an internal configuration of a printer according to a first exemplary embodiment of the present disclosure.

FIG. **2** is a diagram showing the structure of a process unit.

FIG. **3** is a diagram showing the structure of a charger.

FIG. **4** is a block diagram showing an electrical configuration of a high-voltage power supply device.

FIG. **5** is a diagram showing an output control flow of a voltage applying circuit.

FIG. **6** is a block diagram showing an electrical configuration of a printer.

FIG. **7** is a block diagram showing an electrical configuration of a high-voltage power supply device according to a second exemplary embodiment of the present disclosure.

FIG. **8** is an enlarged diagram of a part of FIG. **7**.

FIG. **9** is a diagram showing a modified example of the output control flow of the voltage applying circuit.

FIG. **10** is a block diagram showing an electrical configuration of a high-voltage power supply device according to a third exemplary embodiment of the present disclosure.

FIG. **11** is a diagram showing another configuration example of the printer.

FIG. **12** is a block diagram showing an electrical configuration when the high-voltage power supply device is divided into two systems.

DESCRIPTION OF EXEMPLARY EMBODIMENTS

First Exemplary Embodiment

The first exemplary embodiment of the present disclosure will be described with reference to FIGS. **1** to **6**.

1. Overall Configuration of Printer

FIG. **1** is a schematic cross-sectional view showing an internal configuration of a printer **1** which is an image forming apparatus according to the exemplary embodiment of the present disclosure. In a description provided below, in the case in which the respective components are distinguished from each other by each color, suffixes of B (black), Y (yellow), M (magenta), and C (cyan) are attached to reference numerals of the components, whereas in the case in which the components are not distinguished from each other, the suffixes are omitted.

The printer **1** includes a feeding unit **3**, an image forming unit **5**, a transporting mechanism **7**, a fixing unit **9**, a belt cleaning mechanism **20**, and a high-voltage power supply device **100**.

A feeding unit **3** is formed at a lowermost part of printer **1** and includes a tray **17** receiving sheets **15** (e.g., papers and OHP sheets) and a pickup roller **19**. Sheets **15** received in tray **17** is taken out one by one by a pickup roller **19** and sent to a transporting mechanism **7** through a transporting roller **11** and a registration roller **12**.

A transporting mechanism **7** transports paper sheets **15** and is provided over the feeding unit **3** in the printer **1**. The transporting mechanism **7** includes a driving roller **31**, a driven roller **32**, and a belt **34**. A belt **34** is bridged between a driving roller **31** and a driven roller **32**. When the driving roller **31** rotates, the surface of belt **34** facing a photosensitive drum **41** moves from a right direction to a left direction in FIG. **1**. As a result, sheets **15** sent from the registration roller **12** are transported toward under the image forming unit **5**.

In the belt **34**, four transfer rollers **33**B, **33**Y, **33**M, and **33**C are provided to correspond to the four photosensitive drums **41**B, **41**Y, **41**M, and **41**C, respectively. The transfer rollers **33** are disposed to face the photosensitive drums **41**B, **41**Y, **41**M, and **41**C with the belt **34** interposed therebetween, respectively.

An image forming unit **5** includes four process units **40**B, **40**Y, **40**M, and **40**C and four exposure devices **49**B, **49**Y, **49**M, and **49**C. The Process units **40**B, **40**B, **40**M, and **40**C are arranged in series in a transport direction of the sheets **15** (e.g., a horizontal direction of FIG. **1**).

The process units **40** have the same structure and include the photosensitive drums for respective colors **41**B, **41**B, **41**M, and **41**C (e.g., a 'photosensitive element' of the present disclosure), a toner case **43** receiving a toner of each color (e.g., a non-magnetic positively-charged mono-component toner), a development roller **45**, and chargers **50**B, **50**Y, **50**M, and **50**C.

In each of the photosensitive drums **41**B, **41**B, **41**M, and **41**C, for example, a positively-charged photosensitive layer is formed on a substrate made of aluminum and the aluminum substrate is connected to a ground of printer **1**.

A development roller **45** is disposed to face a feeding roller **46** under a toner case **43** and serves to feed the toner onto the photosensitive drums **41**B, **41**B, **41**M, and **41**C as a uniform thin layer by frictionally charging the toner to positive polarity by friction accompanied by rotation when the toner passes between the development roller **45** and the feeding roller **46**.

Each of the chargers **50**B, **50**Y, **50**M, and **50**C is a Scorotron type charger and includes a shield case **51**, a wire **53**, and a metallic grid electrode **55** as shown in FIGS. **2** and **3**. The shield case **51** has a rectangular cylindrical shape which elongates in a rotational axis direction of the photosensitive drum **41**. A surface of the shield case **51** facing to the photosensitive drum **41** is opened to form a discharge port **52**.

The wire **53** is made of, for example, a tungsten wire. The wire **53** extends in a rotational axis direction (e.g., a horizontal direction of FIG. **3**) in shield case **51** and high voltage is applied to wire **53** by a voltage applying circuit **200** to be described below. The wire **53** causes a corona discharge in the shield case **51** by the application of high voltage. In addition, ions generated by the corona discharge flows from the discharge port **52** to the photosensitive drum **41** as a discharge current to uniformly charge the surface of the photosensitive drum **41** to the positive polarity.

A plate-like grid electrode **55** having a slit or a through-hole is attached to the discharge port **52** of the shield case **51**. Voltage is applied to the grid electrode **55** and the applied voltage is controlled and thereby controls charged voltage of the photosensitive drum **41**.

A wire cleaner **57** (e.g., a 'cleaning unit' of the present disclosure) is provided in the chargers **50**B, **50**Y, **50**M, and **50**C. The wire cleaner **57** is configured to be slidably movable along the wire **53**. An operator reciprocates the wire cleaner **57** along the wire **53** to remove contaminants of the wire **53**.

Each of the exposure devices **49**B, **49**Y, **49**M, and **49**C includes for example, a plurality of light emitting elements (e.g., LEDs or laser light sources) arrayed in series in the rotation axis direction of the photosensitive drums **41**B, **41**Y, **41**M, and **41**C and emits light according to image data inputted from the outside and thereby to form an electrostatic latent image on the surface of each of the photosensitive drums **41**B, **41**Y, **41**M, and **41**C.

A series of image forming processes by the laser printer **1** configured as described above will be described in brief below. When the printer **1** receives print data D (see, e.g., FIG. **6**), the printer **1** starts print processing. As a result, the surface of each of the photosensitive drums **41**B, **41**Y, **41**M, and **41**C is uniformly charged to be the positive polarity by each of the chargers **50**B, **50**Y, **50**M, and **50**C according to its rotation. A laser beam is irradiated to each of the photosensitive drums **41**B, **41**Y, **41**M, and **41**C from each exposure device **49**. As a result, in the case of the surface of each of the photosensitive drums **41**B, **41**Y, **41**M, and **41**C, a potential drops at a portion of the surface of each of the photosensitive drums **41**B, **41**Y, **41**M, and **41**C that have a predetermined electrostatic latent image depending on the print data, that is, are uniformly charged positive to which the laser beam is irradiated.

Subsequently, by the rotation of the development roller **45**, the toner that is adhered to the development roller **45** and positively charged is supplied to the electrostatic latent image formed on the surface of each of photosensitive drums **41**B, **41**Y, **41**M, and **41**C. As a result, the electrostatic latent image of each of the photosensitive drums **41**B, **41**Y, **41**M, and **41**C becomes a visualized image, such that a toner image by reversal development is formed on the surfaces of the photosensitive drums **41**B, **41**Y, **41**M, and **41**C.

Concurrently with the processing for forming the toner image described above, the processing for transporting the sheets **15** is performed. That is, sheets **15** are delivered to a paper transport path Y from tray **17** one by one by the rotation of pickup roller **19**. The sheets **15** conveyed to paper transport path Y is transported to a transfer location (e.g., a point where photosensitive drum **41** and transfer roller **33** contact each other) by the transport roller **11** and the belt **34**.

Therefore, when the sheets **15** pass through the transfer location, the toner image (e.g., a developer image) of each color formed on the surface of each photosensitive drum **41** is sequentially superposed and transferred on the surfaces of the sheets **15** by the transfer bias applied to each transfer roller **33**. Therefore, the toner images (e.g., developer images) of the colors are formed on the sheets **15**. Thereafter, when the sheets **15** pass through the fixing unit **9** provided in the rear side of belt **34**, the transferred toner image (e.g., a developer mage) is thermally fixed and sheets **15** are ejected onto an ejection tray **60**.

2. Configuration of High-Voltage Power Supply Device **100**

A high-voltage power supply device **100** includes a voltage applying circuit **200**, a constant-voltage circuit **250**, a current detecting unit **260**, and a control device **110**.

A voltage applying circuit **200** includes a PWM signal smoothing circuit **210**, a trans-drive circuit **220**, an output circuit **230**, and a voltage detecting circuit **240** and serves to apply high voltage of approximately 6 kV to 7 kV to each charger **50**. The PWM signal smoothing circuit **210** smoothes a PWM signal S**1** outputted from a PWM port A of the control device **110** and outputs the smoothed signal to the trans-drive circuit **220**. The trans-drive circuit **220** is constituted by for example, an amplification element such as a transistor and applies primary voltage of a level depending on a duty ratio of PWM signal S**1** to a primary winding to a transformer Tr.

An output circuit **230** includes a boosting circuit constituted by a transformer Tr and a smoothing circuit **235** constituted by a diode D and a condenser C, and boosts up the primary voltage inputted from the trans-drive circuit **220** and thereafter, rectifies and outputs the primary voltage that is boosted up. In addition, the wire **53** of each of the chargers **50**B, **50**Y, **50**M, and **50**C is commonly connected to an output line Lo of the output circuit **230**. As a result, the output voltage Vo of the output circuit **230** is applied to the wire **53** of each of the chargers **50**B, **50**Y, **50**M, and **50**C.

An auxiliary wire **231** is provided in the transformer Tr of the output circuit **230**. Voltage of a level depending on secondary voltage of the transformer Tr is generated in an auxiliary wire **231**.

The voltage detecting circuit **240** detects the voltage generated in the auxiliary wire **231** and inputs the detected voltage into an A/D port P**1** of the control device **110**. As a result, data of secondary voltage of the transformer Tr is received in the control device **110**.

As shown in FIG. **4**, the grid electrode **55** of each of the chargers **50**B, **50**Y, **50**M, and **50**C is connected to a ground GND through a common connection line L**1** in the exemplary embodiment. In addition, the constant-voltage circuit **250** and the current detecting unit **260** are provided on the common connection line L**1**.

The constant-voltage circuit **250** is constituted by three constant-voltage elements (e.g., zener diodes) **251** that are connected in series, and allows the voltage of the grid electrode **55** of each of the chargers **50**B, **50**Y, **50**M, and **50**C to be a constant voltage that amounts to a voltage value produced by multiplying breakdown voltage by 3 (e.g., 250 V×3) per one zener diode.

The current detecting unit **260** is constituted by a first resistor R**1** connected with the constant-voltage circuit **250** in series and connected to the ground GND. A connection point of the first resistor R**1** with the constant-voltage circuit **250** is connected to an A/D port P**2** provided in the control device **110** through a signal line. According to this configuration, voltage which is in proportion to a magnitude of current (e.g., sum Ig**4** of grid currents Ig of four chargers **50**) that flows on the connection line L**1** is inputted into each A/D port P**2**. As a result, by reading the input voltage level, the magnitude of current sum Ig**4** of grid currents Ig of the four chargers **50** can be detected in control device **110**.

A control device **110** controls an output of the voltage applying circuit **200** and includes PWM port A and two A/D ports P**1** and P**2**. The control device **110** can be configured to include a CPU provided therein and configured with an application specific integrated circuit (ASIC). The control device **110** incorporates a nonvolatile storage unit (not shown) and stores various data (e.g., data of (a) to (c) to be described below) for executing an output control flow to be described hereinafter, in the nonvolatile storage unit.

(a) Data of a reference value of current sum Ig**4** of grid currents Ig of the four chargers **50** (e.g. 1 mA).

(b) Data of a target value of output voltage Vo of the voltage applying circuit **200** (e.g., 6 kV).

(c) Data of an upper limit of output voltage Vo of the voltage applying circuit **200** (e.g., 7.5 kV).

It is known that grid current Ig is substantially in proportion to the discharge current If (e.g., see FIG. **8** of the second exemplary embodiment) that flows to photosensitive drum **41** from charger **50**, and the grid current Ig serves as an index representing a level of discharge current If that flows on photosensitive drum **41**. That is, when the grid current Ig flows with a reference value, 250 μA, discharge current If that flows on the photosensitive drum **41** exceeds a target level. In the exemplary embodiment, 1 mA which is a value produced by multiplying the reference value of the grid current Ig, 250 μA by 4 is set as the reference value of the current sum Ig**4** of the grid currents Ig.

Subsequently, referring to FIG. **5**, the output control flow of the voltage applying circuit **200** executed by the control device **110** will be described. The output control flow of the voltage applying circuit **200** is constituted by a two-step control including an initial control (e.g., a constant-voltage control: steps S**10** to S**50**) executed right after print processing starts and a main control (e.g., a constant-current control: steps S**60** to S**120**) executed until print processing ends after the initial control.

Initial Control: Constant-Voltage Control

As shown in FIG. **6**, when the print data D is outputted from a higher-level device such as a host computer, the print data D is received in the printer **1** through an interface IF. Then, a print processing start command is given to the control device **110** of the high-voltage power supply device **100** from a main control unit **80** that controls and manages the overall operation of printer **1**. As a result, the control device **110** starts the output control flow of FIG. **5** to set the output voltage Vo of the voltage applying circuit **200**, that is, a target value of application voltage applied to the wire **53** of each of the chargers **50**B, **50**Y, **50**M, and **50**C to 6 kV (step S**10**).

Subsequently, the control device **110** adjusts the duty ratio of PWM signal S**1** on the basis of the input voltage (e.g., the voltage value detected by voltage detection circuit **240**) of A/D port P**1**. Therefore, the primary voltage of the transformer Tr is controlled by the trans-drive circuit **220**, such that output voltage Vo of the voltage applying circuit **200** is adjusted to the target value, 6 kV (e.g., S**20**, constant-voltage control).

When the output voltage Vo is stabilized at the target value, 6 kV, the control device **110** calculates the current sum Ig**4** of the grid currents Ig from the input voltage of A/D port P**2**. In addition, the current sum Ig**4** of the grid currents Ig is compared with the reference value to judge whether the current sum Ig**4** is higher than the reference value (step S**30**). In this example, since the reference value is set to 1, it is judged whether the current sum Ig**4** of the grid currents Ig is equal to or higher than 1 mA.

In the judgment processing of step S**30**, if current sum Ig**4** of the grid currents Ig is less than the reference value, it is determined that the judgment is NO. If the judgment in step S**30** is NO, steps S**40** and S**50** are sequentially performed in control device **110**. First, in step S**40**, it is judged whether output voltage Vo of voltage applying circuit **200** is equal to or higher than the upper limit.

The judgment is employed to prevent output voltage Vo from being excessively increased. In this example, the upper limit of the output voltage Vo is set to 7.5 kV and if output voltage Vo is lower than the upper limit, the judgment in step S**30** is NO, and then, step S**50** is performed by the control device **110**.

In step S**50**, the target value of output voltage Vo is changed and boosted up by 200 V. As a result, the target value of the application voltage is changed from 6 kV to 6.2 kV.

Thereafter, as described above, in step S**20**, the output voltage Vo of the voltage applying circuit **200** is adjusted, and in step S**30**, it is judged again whether the current sum Ig**4** of the grid current Ig is higher than the reference value, 1 mA. In addition, if the judgment in step S**30** is NO, the target value of the application voltage is changed again and boosted up by 200 V in step S**50** after the judgment of step S**40**.

Further, if the current sum Ig**4** of grid current Ig is higher than the reference value, 1 mA, the judgment is YES in step S**30**. If the judgment is YES in step S**30**, the initial control ends and the main control is performed after step S**60**.

Main Control: Constant-Current Control

When control device **110** executes the main control, control device **110** controls output voltage Vo of voltage applying circuit **200** so that the current sum Ig**4** of the grid currents Ig is a constant current having the reference value, 1 mA. Specifically, the control device **110** controls the output voltage Vo by adjusting the duty ratio of a PWM signal S**1** outputted from PWM port A on the basis of the input voltage level of A/D port P**2**. Meanwhile, although the current sum Ig**4** is subjected to the constant-current control using the reference value, 1 mA, in this example, the current sum Ig**4** may be subjected to the constant-current control using other values, such as, for example, 1.2 mA, as long as the current sum Ig**4** is equal to or higher than the reference value.

Following step S**60**, it is judged whether output voltage Vo of the voltage applying circuit **200** is equal to or higher than the upper limit, 7.5 kV in step S**70**. If output voltage Vo is lower than the upper limit, the process for step S**80** is performed, and thereafter, in step S**90**, a process of storing output voltage Vo is performed in the control device **110**.

Thereafter, the process proceeds to step S**100** and it is judged whether a process of applying high voltage to charger **50** is completed by the control device **110**. Since it is judged that the application process of high voltage is completed when printer **1** completes the print processing, the judgment in step S**100** is NO during the printing processing, and the process returns to step S**60**.

As described above, until the application process of high voltage is completed, the processes of steps S**60** to S**100** are repeatedly performed except for the case that the judgment is No in steps S**70** and S**80**, and the current sum Ig**4** of the grid currents Ig is continually subjected to the constant-current control using the reference value, 1 mA.

As such, when current sum Ig**4** of grid currents Ig is subjected to the constant-current control using the reference value, 1 mA, the grid current Ig of each of the chargers **50**B, **50**Y, **50**M, and **50**C has a current value of approximately 205 μA although the current value is somewhat varied. As a result, the discharge current If (see, e.g., FIG. **8** of the second exemplary embodiment) of an appropriate amount sufficient to avoid the deterioration of an image quality flows from each charger **50** to each photosensitive drum **41**, such that the charge amount of each photosensitive drum **41** may be equal to or higher than a target level.

If the printer **1** terminates the print processing, the control device **110** judges that the application process of high voltage to each of the chargers **50**B, **50**Y, **50**M, and **50**C is completed. As a result, when the judgment of step S**100** is performed, the judgment is YES, thereby a series of processes are completed first. In addition, when print data D outputted from the higher-level device is again received in printer **1**, the print processing start command is given to control device **110** of the high-voltage power supply device **100** from the main control unit **80**. As a result, the sequential processes are performed from step S**10** again, such that in the main control, output voltage Vo of voltage applying circuit **200** is controlled so that the current sum Ig**4** of the grid currents Ig becomes the constant current having the reference value, 1 mA.

Meanwhile, during the constant-current control, the output voltage Vo of the voltage applying circuit **200** tends to increase, because when the wire **53** gets dirty by the use, grid current Ig decreases, and as a result, control device **110** controls the level of the output voltage Vo of the voltage applying circuit **200** to be increased to supplement the decreased current amount. If the output voltage is excessively higher, there is a possibility that the wire **53** of the charger **50** will cause an abnormal discharge.

In view of the above, it is judged in step S**70** whether the output voltage Vo of the voltage applying circuit **200** is equal to or higher than the upper limit in this exemplary embodiment. In addition, when the output voltage Vo is higher than the upper limit, the judgment is YES in step S**70**, and thereafter, the process proceeds to step S**110**. Similarly, the process proceeds to step S**110** if the judgment is YES in step S**40**, that is, output voltage Vo is higher than the upper limit in the initial control step. In step S**110**, a message for urging an operator to clean the wire **53** of each charger **50** is notified. Specifically, the control device **110** displays a message for urging the operator to clean the wire on a monitor (not shown) provided in the printer **1**.

If the message for urging the operator to clean the wire is displayed, the operator who sees the message may remove contaminants of the wire **53** of each charger **50** by using the wire cleaner **57**. Thereafter, since the wire **53** of each charger **50** may be easily discharged, the output voltage Vo of the voltage applying circuit **200** can be decreased, thereby avoiding the abnormal discharge of the wire **53** of each charger **50** in advance.

In some cases, the operator may voluntarily clean only wires **53** of some chargers **50**. In this case, since the current sum Ig**4** of grid currents Ig is made into a constant current, if the wires are different from each other in contamination level, a current value of grid current Ig varies significantly and such variation is undesirable.

In this regard, in the present exemplary embodiment, the control device **110** judges whether the output voltage Vo tends to decrease by comparing the output voltage Vo with previous output voltage Vo in step S**80**. When the operator voluntarily cleans wire **53** of charger **50**, wire **53** is easily discharged, and as a result, the output voltage Vo is lower than the previous output voltage Vo. Therefore, the judgment is YES in step S**80**, and the process proceeds to step S**110**.

As a result, similar the case described above, a message for urging the operator to clean the wire **53** of each charger **50** is notified. As a result, even when the operator voluntarily cleans merely wires **53** of some chargers **50**, the operator cleans the rest of wires **53** by using wire cleaner **57**, thereby avoiding the situation that only some of the wires **53** are cleaned.

As described above, the printer **1** shares a single voltage applying circuit **200** with the chargers **50**B, **50**Y, **50**M, and **50**C. Therefore, the number of components can be reduced as compared with a case in which the exclusive voltage applying circuits **200** are provided for the chargers **50**B, **50**Y, **50**M, and **50**C, respectively.

In the main control step, since the current sum Ig**4** of the grid currents Ig is subjected to the constant-current control using the reference value, 1 mA, each grid current Ig has the current value of approximately 250 μA although the current value is somewhat varied. As a result, the discharge current If of an appropriate amount sufficient to avoid the deterioration of the image quality flows from each charger **50** to each photosensitive drum **41**, such that the charge amount of each photosensitive drum **41** may become equal to or higher than the target level. Accordingly, the image quality can be prevented from deteriorating due to the shortage of the charge amount. Further, for example, when each of the grid currents Ig is detected, the current detecting unit is required for each grid electrode **55**. In this example, since the current sum Ig**4** of the grid currents Ig is detected, only one current detecting unit **260** is used. Accordingly, the circuit can be configured by the small number of components.

Further, in the exemplary embodiment, since the grid voltages of all chargers **50**B, **50**Y, **50**M, and **50**C are made into a constant voltage through one constant-voltage circuit **250**, the circuit can be configured with smaller number of components as compared with a case where constant-voltage circuit **250** is provided for each of chargers **50**B, **50**Y, **50**M, and **50**C. In addition, when constant-voltage circuit **250** is commonly used, the voltage levels of grid electrodes **55** of chargers **50** are the same with each other, and as a result, the charged voltages of each of photosensitive drums **41** can be controlled by using approximately the same charged voltage.

Second Exemplary Embodiment

The second exemplary embodiment of the present disclosure will be described with reference to FIGS. **7** to **9**.

In the first exemplary embodiment, the current sum Ig**4** of the grid currents Ig is subjected to the constant-current control using the reference value (e.g., 1 mA). In the second exemplary embodiment, a current sum Iw**4** of wire currents

Iw that flows on the wires **53** of the chargers **50** is subjected to the constant-current control using a reference value (e.g., 1.1 mA).

In order to detect the current sum Iw**4** of the wire currents Iw, a current detecting resistor may be provided on a current return path Lr for the voltage applying circuit **200**. More specifically, referring to FIG. **7**, one end of the secondary wire of transformer Tr of output circuit **230** of voltage applying circuit **200** is adapted to as an output terminal U, and the wires **53** of the chargers **50**B, **50**Y, **50**M, and **50**C are commonly connected to an output line Lo drawn from output terminal U. Grid electrode **53** of each of the chargers **50**B, **50**Y, **50**M, and **50**C is connected to the ground GND through the connection line L**1**. In addition, a constant-voltage circuit **250** constituted by three constant-voltage elements (e.g., zener diodes) that are connected in series is provided on the connection line L**1**.

Meanwhile, the other end of the secondary wire of transformer Tr is connected to an output terminal (e.g., 5V) of a low-voltage power supply circuit **280** through connection line Lr.

As described above, all of the currents that flow out to the chargers **50** from the output terminal U of the voltage applying circuit **200**, that is, current sum Iw**4** of wire currents Iw all return to the voltage applying circuit **200** through the connection line Lr. That is, connection line Lr serves as a common return path for returning wire currents Iw of each of the chargers **50** to the voltage applying circuit **200**.

In addition, wire currents Iw flow by being divided into grid current Ig that flows to the grid electrode and discharge current If that flows to photosensitive drum **41** at a ratio of approximately 9:1, as shown in FIGS. **7** and **8**. However, since both currents Ig and If flow into the ground GND, wire currents Iw in which both currents Ig and If are joined flow on a common return path Lr drawn from the output terminal of low-voltage power supply circuit **280**.

A second resistor R**2** serving as current detecting unit **260** is provided on the common return path Lr. The Second resistor R**2** is connected to each A/D port P**2** provided in the control device **110** through the signal line. As described above, a voltage which is in proportion to the magnitude of the current (e.g., current sum Iw**4** of wire currents Iw) that flows on the common return path Lr is inputted into A/D port P**2**. As a result, by referring to the input voltage of port P**2**, the magnitude of the current sum Iw**4** of the wire currents Iw can be detected in the control device **110**.

Meanwhile, the common return path Lr is drawn from the output terminal of the low-voltage power supply circuit **280** because the control device **110** cannot read a minus voltage and the voltage level is increased in order for that voltage of a voltage withdrawing point Pr does not become minus voltage.

In the second exemplary embodiment, the output control flow of the voltage applying circuit **200** executed by control device **110** is the same as the output control flow of the first exemplary embodiment except that the current sum Ig**4** of the grid currents Ig is substituted by the current sum Iw**4** of the wire currents Iw. As shown in FIG. **9**, the output control flow is performed by a two-step control including the initial control (e.g., the constant-voltage control: steps S**10** to S**50**) performed just after the print processing starts and the main control (e.g., the constant-current control: steps S**60** to S**120**) performed until the print processing is completed after the initial control. In addition, in the main control step, the current sum Iw**4** of the wire currents Iw is subjected to the constant-current control using the reference value, 1.1 mA by the control device **110**.

As such, when the current sum Iw**4** of the wire currents Iw is subjected to the constant-current control using the reference value, 1.1 mA, each wire current Iw has a current value of approximately 270 to 280 μA although the current value is somewhat varied. As a result, the discharge current If of the appropriate amount sufficient to avoid the deterioration of the image quality flows from each charger **50** to each photosensitive drum **41**, such that the charge amount of each photosensitive drum **41** may be made equal to or higher than the target level. Accordingly, the image quality can be prevented from deteriorating due to the shortage of the charge amount.

Third Exemplary Embodiment

Third exemplary embodiment of the present disclosure will be described with reference to FIG. **10**. The third exemplary embodiment automatizes the cleaning of the wires **53** and further includes a motor drive circuit **291** and a motor **295** in addition to the electrical components of the first exemplary embodiment. The motor **295** serves as a driving source of a reciprocating device (not shown) that allows wire cleaner **57** (e.g., the 'cleaning unit' of the present disclosure) to reciprocate along wires **53**.

The motor drive circuit **291** controls motor **295** on the basis of a control signal S**2** outputted from the control device **110**. In addition, the control device **110**, for example, the drives motor **295** by giving the control signal S**2** to the motor drive circuit **291** for every 200 print sheets. As a result, the reciprocating device is actuated, such that the wire cleaner **57** automatically cleans the wires **53** of the chargers **50**.

Thus, since the wire **53** of each charger **50** can be kept clean at all times, the image quality does not deteriorate even though the number of print sheets increases over the period of time usage. Meanwhile, although only one motor drive circuit **291** and one motor **295** are shown in FIG. **10**, the wire **53** is provided for each charger **50**, and thus, the motor drive circuit **291** and the motor **295** also need to be provided for each charger **50**. For example, for every 200 print sheets, the control device **110** drives each motor **295** by giving the control signal S**2** to each motor drive circuit **291** to automatically clean the wires **53** of the chargers **50** by using each of the wire cleaners **57** at one time, respectively. Meanwhile, automatic cleaning timings of wires **53** may not completely be the same.

Other Exemplary Embodiment

The present disclosure is not limited to the exemplary embodiments described by the technologies and drawings, but for example, the following exemplary embodiment also belongs to the scope of the present disclosure.

(1) In the first to third exemplary embodiments, as a configuration example of the printer **1**, the printer **1** having one charger **50** corresponding to one photosensitive drum **41** (e.g., printer **1** having photosensitive drum **41** for each color) has been described. The present disclosure may be applied to a printer **1** in which plural chargers **310** and **320** are placed to correspond to one photosensitive drum **300** as shown in FIG. **11** (e.g., the printer **1** in which toner images of respective colors are superposed on the photosensitive drum **300** and thereafter, are transferred on the sheets at one time). Meanwhile, reference numeral **315** in FIG. **11** represents a process unit (e.g., a developer) that makes up a group with the charger **310** and reference numeral **325** represents a process unit that makes up a group with the charger **320**.

In the first exemplary embodiment, the current sum Ig**4** of the grid currents Ig is subjected to the constant-current control using the reference value, 1 mA. It was intended to set the grid current Ig of each charger **50** to the reference value of approximately 250 μA. The grid current Ig of each charger **50** can be made equal to or higher than the reference value by performing a constant-voltage control on the output voltage Vo of the voltage applying circuit **200** instead of the constant-current control. That is, the output voltage Vo may be subjected to the constant-voltage control with a voltage value with which the current sum Ig**4** (Iw**4** is also the same) of the grid currents Ig may be made higher than the reference value, 1 mA.

Further, in the case in which output voltage Vo is subjected to the constant-voltage control, when the degree of wire contamination is changed, the changed contamination degree is shown as a change of the current sum Ig**4** (Iw**4** is also the same). For example, when the wires are becoming contaminated, the current sum Ig**4** tends to accordingly decrease, such that a reduction level of current sum Ig**4** is substantially in proportion to a progressed degree of the wire contamination. Accordingly, the data for current sum Ig**4** (e.g., the input value of A/D port P**2**) is stored at the time of detecting the current sum Ig**4** and thereafter, a difference between the present current sum Ig**4** and the current sum Ig**4** at the time of previous detection is acquired. In addition, when the difference of the current sums Ig**4** becomes higher than an acceptable value, if a message urging the operator to clean each wire **53** is notified to the operator by the control device **110**, the cleaning can be performed when the wire contamination is rapidly progressed.

(3) In the first to third exemplary embodiments, there is described a configuration example in which the four chargers **50** are commonly connected to the output line Lo of the voltage applying circuit **200**. All of the four chargers do not need to be commonly connected to voltage applying circuit **200** and each two sets of chargers may be commonly connected to each voltage applying circuit by dividing the voltage applying circuit into two systems shown in FIG. **12**. In addition, if the voltage applying circuit is divided into two systems as shown in FIG. **12**, a current sum Ig**2** of the grid currents Ig may be detected for each system to individually constant-current control respective current sum Ig**2**.

(4) In the second exemplary embodiment, as one example of charger **50**, Scorotron charger having grid electrode **55** is described, but a corona discharge type charger may also be applied and a Scorotron charger may also be used without the grid electrode.

(5) In the first to third exemplary embodiments, as one example of the constant-voltage element, the zener diode is described, but a varistor may be used as well. Further, the resistance detection type current detecting unit is described as one example of the current detecting unit **260**, but a current sensor using a hall element may also be used.

What is claimed is:

1. An image forming apparatus, comprising:

at least one photosensitive element;

a plurality of chargers configured to charge the at least one photosensitive element;

a voltage applying circuit commonly connected to the plurality of chargers and configured to apply a voltage to the plurality of chargers;

a current detecting unit configured to detect a current sum of currents of the plurality of chargers; and

a control device configured to control the voltage applying circuit so that the current sum detected by the current detecting unit becomes equal to or larger than a reference value,

wherein the plurality of chargers are Scorotron chargers having wires and grid electrodes,

wherein the grid electrode of each of the Scorotron chargers is connected to ground through a common connection line, and

wherein the current detecting unit includes a resistor provided at the common connection line and a constant-voltage element provided at the common connection line between the plurality of chargers and the resistor, the current detecting unit configured to detect a voltage at a point between the resistor and the constant-voltage element to detect the current sum.

2. The image forming apparatus according to claim **1**, wherein the control device controls an output voltage of the voltage applying circuit so that the current sum becomes a constant current that is equal to or larger than the reference value.

3. The image forming apparatus according to claim **1**, wherein wire current that flows on the wire provided in each of the chargers is adapted to be returned to the voltage applying circuit through a common return path, and

the current detecting unit includes a resistor provided on the common return path and is configured to detect as the current sum a current sum of the wire current of each of the chargers.

4. The image forming apparatus according to claim **2**, further comprising a voltage detecting circuit configured to detect the output voltage of the voltage applying circuit,

wherein the control device provides a message notifying an operator to clean a wire if the output voltage detected by the voltage detecting circuit is decreased as compared to the output voltage detected at a previous detection time.

5. The image forming apparatus of according to claim **1**, further comprising:

a voltage detecting circuit configured to detect an output voltage of the voltage applying circuit,

wherein the control device performs a constant-voltage control of the output voltage of the voltage applying circuit at a voltage level where the current sum becomes equal to or larger than the reference value.

6. The image forming apparatus according to claim **5**, wherein

the plurality of chargers are Scorotron chargers having wires and grid electrodes, and

the grid electrode of each of the Scorotron chargers is connected to a ground through a common connection line including a constant-voltage element.

7. The image forming apparatus according to claim **6**, wherein the current detecting unit includes a resistor provided on the common connection line and is configured to detect as the current sum a current sum of grid current of each of the Scorotron chargers.

8. The image forming apparatus according to claim **5**, wherein wire current that flows on the wire provided in each of the chargers is adapted to be returned to the voltage applying circuit through a common return path, and

the current detecting unit includes a resistor provided on the common return path and is configured to detect as the current sum a current sum of the wire current of each of the chargers.

9. The image forming apparatus according to claim **5**, wherein the control device provides a message notifying an operator to clean a wire provided in each of the chargers if a difference between the current sum detected by the current detecting unit and a current sum detected previously by the current detecting unit exceeds an acceptable value.

10. The image forming apparatus according to claim **1**, wherein

a wire is provided in each of the chargers, a cleaning unit is provided in each of the wires, and

the control device cleans each of the wires by actuating each of the cleaning units for a predetermined period.

11. The image forming apparatus according to claim **1**, wherein a plurality of the photosensitive elements is provided to correspond to the plurality of chargers.

12. The image forming apparatus according to claim **1**, wherein

the plurality of chargers is connected to ground through a common connection line,

the current detecting unit includes a resistor provided on the common connection line and is configured to detect a voltage at one end of the resistor to detect the current sum.

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